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THE COLORS OF THE CRAYFISH.

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SOME time has been devoted during the past year to a study of the influence of environment upon the colors of the crayfish. The work has been confined in a large part to the species *Cambarus immunis*.

It was first noticed, while studying the habits of crayfish by observations in field work, that the color of *immunis* in nearly all cases closely resembled the color of the environment. In one small pond of water, where the soil at the bottom was a blue clay, the crayfish were all blue in color. In another pond with a black, muddy bottom they were all black, and in still other places of different colors. But in nearly all cases they were of the same color as the environment.

One exception to this was found with those which were red. These were confined entirely to the shallow water in the small streams, and the color was not always similar to the color of the environment. The crayfish in all colors except red were found almost entirely in the ponds with deeper water and muddy bottoms. But it was discovered later that this red color in crayfish may be caused by exposure to sunlight. This was first observed while making a microscopic study of the pigment, to which most of the color of the crayfish is due. This pigment when removed from the crayfish and exposed to the sunlight turned red in a short time. The same result occurred when all effects of heat were excluded by using diffused light and an alum bath.

The influence of sunlight upon the color of living crayfish was studied further by experimenting in the laboratory. Crayfish of various colors were kept in an aquarium exposed to the light. This is a difficult experiment to carry out. Crayfish which live in deeper water become strongly photopathic and can endure only very weak light. It was necessary at first to place the aquarium with the crayfish in diffused light and to allow them to become accustomed by degrees to changed conditions.

Some very good results were obtained in these experiments. Crayfish in black, blue, and green colors were changed to brown and red under the influence of light. These color changes, however, were very slow. Several months were required to produce distinct changes.

Other experiments were made in the laboratory upon the influence of environment on the color of the crayfish. A number were taken from different places where they were of various colors and kept for some time in an aquarium. This aquarium tank was made of zinc and was partly covered to exclude the light. In some cases very distinct color changes occurred. This was especially true of those which were red and black. Out of a large number of crayfish of different colors which were kept in this way for several months, nearly all were changed to the same gray color of the zinc aquarium.

An excellent illustration of color changes is furnished by another species, *Cambarus diogenes.* These may be found in any of the smaller streams. In the early spring they vary much in color, but later in the year nearly all are red. The explanation here lies in the habits of this species. They burrow during winter and come out in the spring with more or less of the color of the soil. These colors are gradually turned to red in the open sunlight. There has been no opportunity for observations upon other burrowing crayfish, but what is true of *diogenes* is no doubt true of other species which burrow in winter.

Some little time was also spent in studying color changes in the young crayfish. This study was made during the months of April and May of the present year, and was confined to one species, *immunis.* The young of *immunis* are at first red. This red color, however, is not apparent to the unaided eye. The pigment layer of a young crayfish consists of a number of large chromatophores which lie directly below the chitinous integument. These color bodies are somewhat scattered, and the little color they give is scarcely noticeable in comparison with the colors of some of the internal organs, which can also be seen. The color of the young crayfish should be studied with the microscope. The integument of the young crayfish is perfectly transparent, and with a microscope any changes in color in the chromatophores is easily observed.

A series of observations was made upon the young crayfish in one pond where the old were black and in another pond where the old were blue. In this pond where the old crayfish were black the young were at first red and gradually changed to black. This change of color required about two months' time. In crayfish one or two weeks old only a very few of the chromatophores showed any change in color, while in crayfish one month old possibly one-half of them would be changed in color, and in those from two to three months old the process of color change was nearly always complete. The integument remains transparent up to this age, so that all stages in color changes were readily seen.

In the second pond where the old crayfish were blue the young, which were red at first, changed to blue, this change requiring about the same length of time. In other places where the old crayfish were red the young crayfish underwent no change in color. They were red at first and remained red in color. In this work the young crayfish of different ages were brought into the laboratory and examined. The color changes were such as occur among crayfish in their natural environment and under ordinary conditions. No attempt was made to keep them in the laboratory for the purpose of experiments.

From these observations it will be seen that the colors of crayfish are due to two causes. The sunlight produces the red color, though this same color may be caused by the environment. All colors excepting red are due to the influence of environment. In all cases these colors serve as a protection against enemies.

The greater part of this work has been confined to one species, *Cambarus immunis*, although some work has been done on three other species, *propinquus*, *bartonii*, and *diogenes*. But there seems to be no reason why similar changes in color should not occur among all other species.

A word should be said here against too hasty conclusions on this subject of colors. Many species of crayfish are migratory in their habits. This is especially true of those living in running water. The changes in color require some weeks or possibly months of time. For these reasons the color of crayfish seen in the small streams may not be at all like the color of the environment. The best results will be obtained from a study of the crayfish in the small ponds of water where migrations cannot occur.